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Minami

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(54) **ELECTRONIC APPARATUS, WATER DETECTION MEANS CONTROL METHOD, AND ELECTRONIC APPARATUS OPERATION MODE SETTING METHOD**

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CPC ***H04M 1/18*** (2013.01); ***H04M 1/72569*** (2013.01); ***H04N 5/232*** (2013.01); ***H04W 52/0245*** (2013.01); ***H04W 52/0251*** (2013.01); *H04M 2250/12* (2013.01)

(58) **Field of Classification Search**
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USPC 455/556, 418, 3.06, 420, 13.4, 41.3, 455/67.11, 552.1, 556.1, 557; 348/223.1, 348/207.1, 234, 222.1, 143, 136, 195, 371; 340/573.4, 573.6; 396/155; 73/73
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,382,499 A * 1/1995 Keelan et al. 430/503
5,963,130 A 10/1999 Schlager et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1736087 A 2/2006
CN 101206384 A 6/2008
(Continued)

OTHER PUBLICATIONS

Communication dated Jul. 7, 2014, issued by the European Patent Office in counterpart European application No. 12744429.7.
(Continued)

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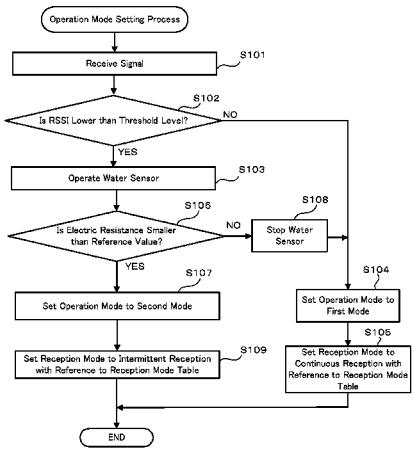
(57) **ABSTRACT**

An electronic device (**10**) is capable of operating in water. The electronic device (**10**) has communication means (**120**), water detection means (**35**), and control means (**100**). The communication means (**120**) receives a radio wave. The water detection means (**35**) detects whether the electronic device (**10**) is immersed in water or not. The control means (**100**) makes the water detection means (**35**) operate in the case where intensity of a reception signal of the radio wave received by the communication means (**120**) is lower than a threshold level.

10 Claims, 7 Drawing Sheets



(51) **Int. Cl.**
H04M 1/725 (2006.01)
H04N 5/232 (2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,026,288	A *	2/2000	Bronner	H04B 1/26 455/254
6,489,895	B1 *	12/2002	Apelman	G01M 3/18 137/312
6,631,264	B1 *	10/2003	Leickel	H04W 36/30 455/434
8,311,595	B2 *	11/2012	Takatsuka et al.	455/575.1
8,432,452	B2 *	4/2013	Moriyama	348/207.1
8,979,554	B2 *	3/2015	Yudate	439/76.1
9,013,036	B2 *	4/2015	Yeh	257/710
2002/0021227	A1 *	2/2002	Mizuno	G07C 5/008 340/904
2002/0052159	A1 *	5/2002	Eguchi	441/80
2002/0175820	A1 *	11/2002	Oja	G08B 21/0222 340/573.4
2003/0210147	A1 *	11/2003	Humbard	340/573.1
2004/0092200	A1 *	5/2004	Ishimoto	A63H 23/04 446/153
2004/0108861	A1 *	6/2004	Germiquet et al.	324/663
2004/0176127	A1 *	9/2004	Ballantyne	G01S 19/34 455/552.1
2006/0016896	A1	1/2006	Grupp	
2006/0114335	A1 *	6/2006	Hara	H04N 9/735 348/223.1
2006/0202839	A1	9/2006	Vannerus et al.	
2007/0030156	A1 *	2/2007	Schlager	A61N 1/08 340/573.1
2007/0132578	A1 *	6/2007	Powell	G08B 21/023 340/539.26
2007/0247307	A1 *	10/2007	Riep	340/539.13
2008/0111913	A1 *	5/2008	Okamoto	348/363
2008/0119140	A1 *	5/2008	Maligeorgos	H04B 15/02 455/67.13
2009/0027211	A1 *	1/2009	Cutler et al.	340/573.6
2009/0096896	A1 *	4/2009	Imafuji et al.	348/234
2009/0163144	A1 *	6/2009	Nakatsugawa	H04W 24/10 455/67.13
2009/0189981	A1 *	7/2009	Siann et al.	348/143
2010/0053323	A1 *	3/2010	Izawa	348/136
2010/0328076	A1 *	12/2010	Kyle	G06F 19/327 340/573.1
2011/0019009	A1 *	1/2011	Moriyama	348/207.1
2011/0058085	A1 *	3/2011	Ito et al.	348/333.02
2011/0105100	A1 *	5/2011	Tanaka	H01H 13/702 455/418
2011/0174235	A1 *	7/2011	Vinano et al.	119/712
2011/0187890	A1 *	8/2011	Takayama et al.	348/223.1
2011/0273998	A1 *	11/2011	Mudrick	H04L 43/08 370/252
2014/0043186	A1 *	2/2014	Karayil Thekkoott	G01S 19/03 342/176

FOREIGN PATENT DOCUMENTS

CN	101562702	A	10/2009
JP	2004-015312	A	1/2004
JP	2006-166360	A	6/2006
JP	2008-283406	A	11/2008
JP	2009-229368	A	10/2009
JP	2011-015363	A	1/2011
WO	2009/157568	A1	12/2009

OTHER PUBLICATIONS

Communication dated Nov. 4, 2014 from the State Intellectual Property Office of People's Republic of China in counterpart application No. 201280004373.5.
Communication dated Jul. 17, 2015 from the State Intellectual Property Office of the People's Republic of China in counterpart application No. 201280004373.5.

* cited by examiner

Fig.1A

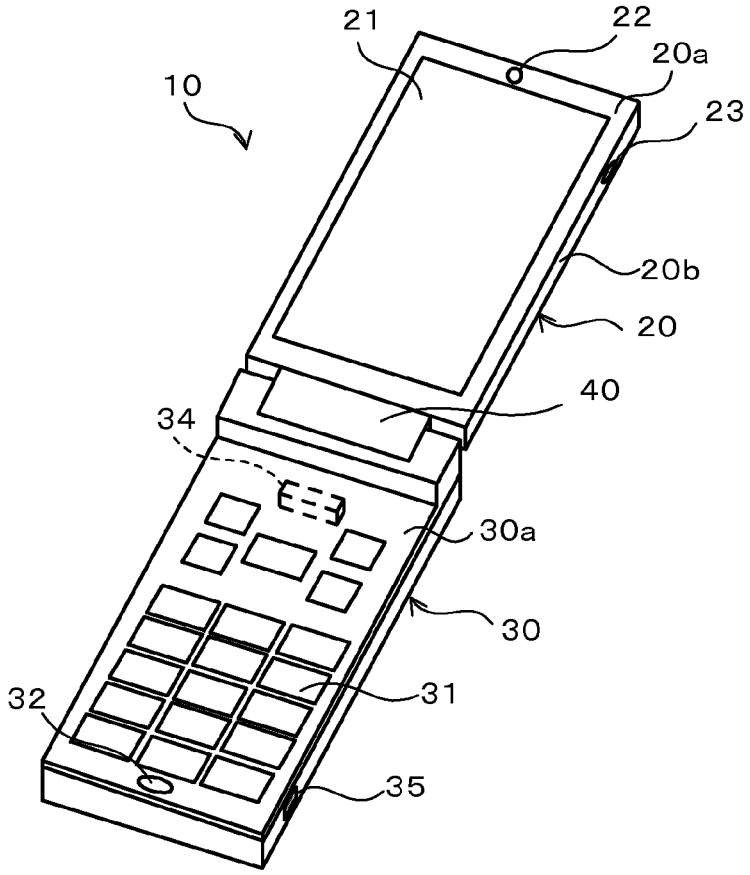


Fig.1B

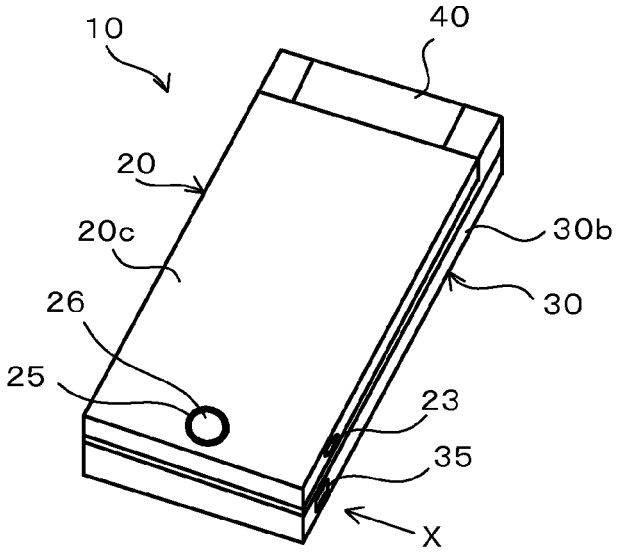


Fig.1C

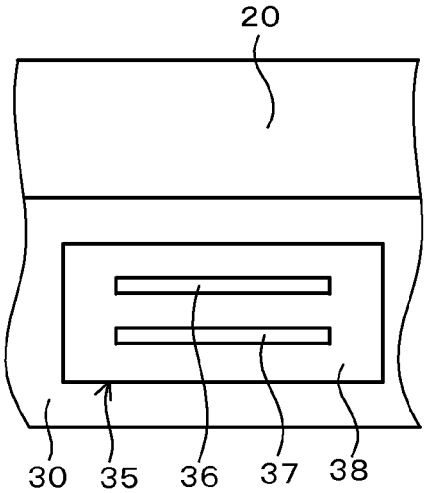


Fig.2

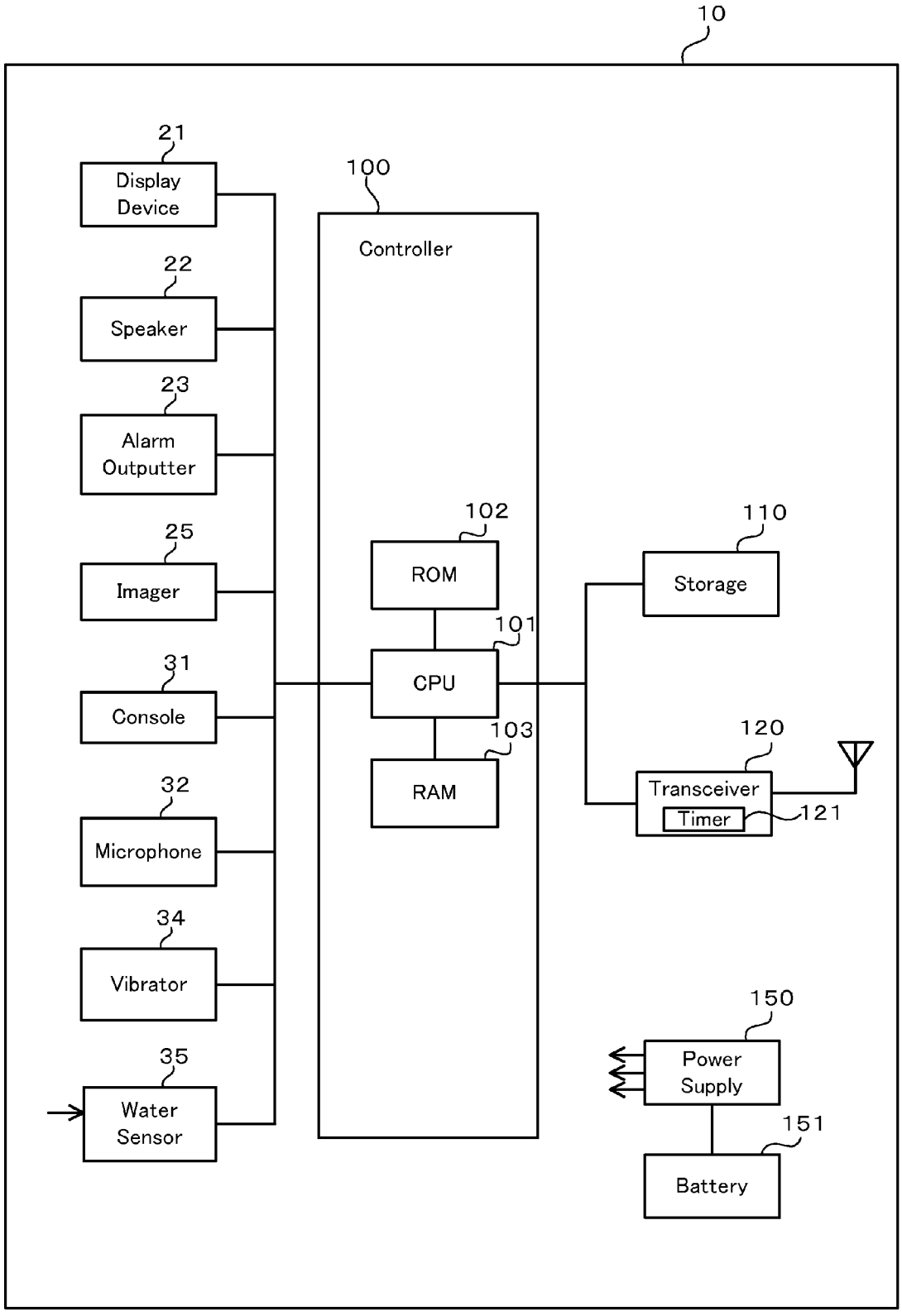

10
21
Display Device
22
Speaker
23
Alarm Outputter
25
Imager
31
Console
32
Microphone
34
Vibrator
35
Water Sensor
100
Controller
102
ROM
101
CPU
103
RAM
110
Storage
120
Transceiver
Timer
121
150
Power Supply
151
Battery

Fig.3A

First Operation Mode

50

Function	Operation State
Verbal Communication Function	ON
Email Function	ON
Imaging Function	ON
Recording Function	ON
Vibrating Function Upon Call Reception	ON

Fig.3B

Second Operation Mode

51

Function	Operation State
Verbal Communication Function	OFF
Email Function	OFF
Imaging Function	ON
Recording Function	OFF
Vibrating Function Upon Call Reception	OFF

Fig.4

60

Operation Mode	Reception Mode
First Operation Mode	Continuous Reception
Second Operation Mode	Intermittent Reception

Fig.5

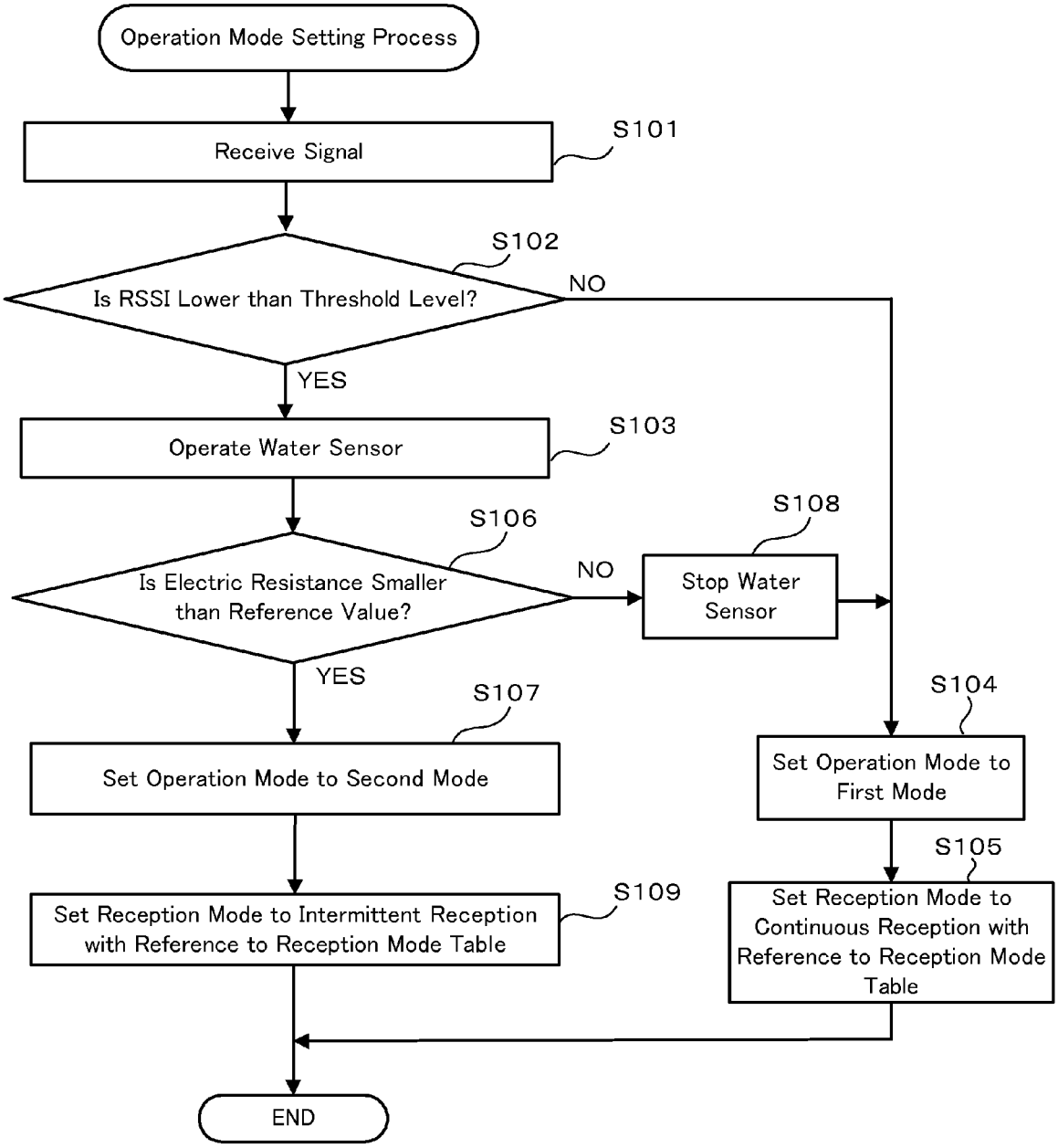

Operation Mode Setting Process
Receive Signal
S101
S102
Is RSSI Lower than Threshold Level?
NO
YES
Operate Water Sensor
S103
S106
Is Electric Resistance Smaller than Reference Value?
NO
S108
Stop Water Sensor
YES
S107
Set Operation Mode to Second Mode
S104
Set Operation Mode to First Mode
S105
Set Reception Mode to Intermittent Reception with Reference to Reception Mode Table
S109
Set Reception Mode to Continuous Reception with Reference to Reception Mode Table
END

Fig.6A

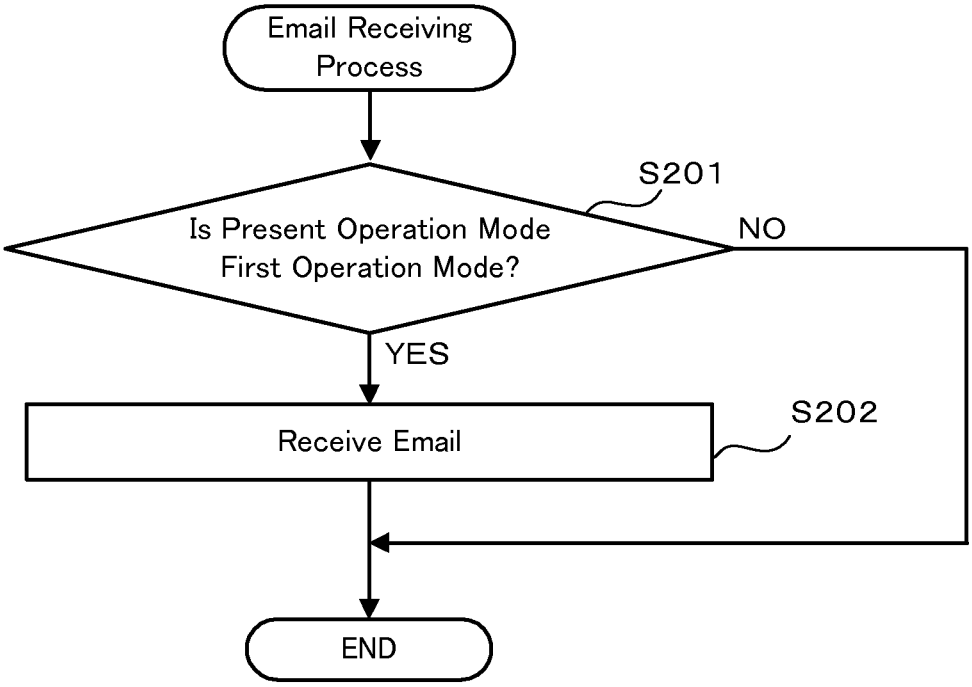

Email Receiving Process
S201
Is Present Operation Mode First Operation Mode?
NO
YES
S202
Receive Email
END

Fig.6B

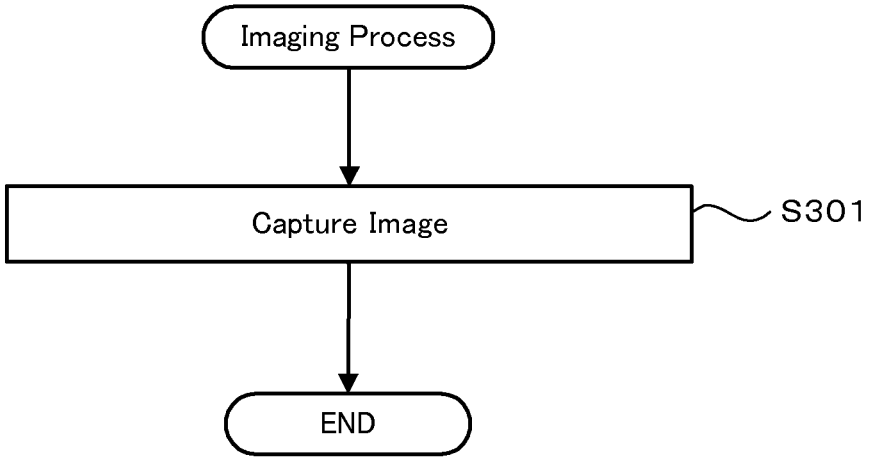

Imaging Process
Capture Image
S301
END

Fig.7A

First Operation Mode

70

Imaging Parameter	Imaging Mode
Aperture Value	Regular
Shutter Value	Regular
Value of ISO Sensitivity	Regular

Fig.7B

Second Operation Mode

71

Imaging Parameter	Imaging Mode
Aperture Value	Regular
Shutter Value	Faster than That in First Operation Mode
Value of ISO Sensitivity	Higher than That in First Operation Mode

ELECTRONIC APPARATUS, WATER DETECTION MEANS CONTROL METHOD, AND ELECTRONIC APPARATUS OPERATION MODE SETTING METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a National Stage of International Application No. PCT/JP2012/052787, filed on Feb. 7, 2012, which claims priority from Japanese Patent Application No. 2011-026390, filed on Feb. 9, 2011, the contents of all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to an electronic device, a water detection means control method, and an electronic device operation mode setting method.

BACKGROUND ART

Some electronic devices such as a cellular phone have predetermined waterproof property. Users are able to use those electronic devices in water.

However, a part of the functions does not work in water. For example, in the case of immersing a cellular phone in water, a radio wave transmitted from a basestation is considerably attenuated by water. Consequently, the cellular phone enters a so-called out-of-service state and the user is unable to use a telephone call function or the like. Nevertheless, the cellular phone repeats receiving operation to receive a communication radio wave, so the power of the battery or the like provided for the cellular phone is consumed.

An electronic device disclosed in Patent Literature 1 stops receiving a radio wave when a detector detects that the device is in water.

PRIOR ART LITERATURE

Patent Literature

Patent Literature 1: Unexamined Japanese Patent Application Kokai Publication No. 2009-229368

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

Power is always supplied to the detector provided for the electronic device described in Patent Literature 1, and power is uselessly consumed.

The present invention is achieved by paying attention to such a problem and an object of the invention is to provide an electronic device that is operable in water and whose power consumption is low.

Means for Solving the Problem

To achieve the object, according to a first aspect of the present invention, there is provided an electronic device that is able to operate in water, including:

communication means that receives a radio wave;

water detection means that detects whether the electronic device is immersed in water or not; and

control means that makes the water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level.

According to a second aspect of the present invention, there is provided a method of controlling water detection means, including:

a step of receiving a radio wave by communication means; and

a step of making water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level.

According to a third aspect of the present invention, there is provided a method of setting an operation mode of an electronic device that is able to operate in water and is able to be set in two operation modes, including:

a step of receiving a radio wave by communication means;

a step of making water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level; and

a step of changing the operation mode of the electronic device from one of the operation modes to the other operation mode in the case where the water detection means detects that the electronic device is immersed in water.

Effects of the Invention

The present invention is able to provide an electronic device that is able to operate in water and whose power consumption is small.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A is a perspective view illustrating a state where a cellular phone according to an embodiment of the present invention is open;

FIG. **1**B is a perspective view illustrating a state where the cellular phone according to the embodiment of the present invention is closed;

FIG. **1**C is an enlarged view from the X direction of arrow in FIG. **1**B;

FIG. **2** is a block diagram illustrating the configuration of the cellular phone according to the embodiment of the invention;

FIG. **3**A is a diagram for explaining an operation state of each of functions in a first operation mode of the cellular phone according to the embodiment of the invention;

FIG. **3**B is a diagram for explaining an operation state of each of functions in a second operation mode of the cellular phone according to the embodiment of the invention;

FIG. **4** is a diagram for explaining a reception mode of a transceiver in the cellular phone according to the embodiment of the invention;

FIG. **5** is a flowchart illustrating operation mode setting process of the cellular phone according to the embodiment of the invention;

FIG. **6**A is a flowchart illustrating email receiving process of the cellular phone according to the embodiment of the invention;

FIG. **6**B is a flowchart illustrating image process of the cellular phone according to the embodiment of the invention;

FIG. **7**A is a diagram for explaining an image capturing mode of the imaging function in the first operation mode of a cellular phone according to a modification of the present invention; and

FIG. **7**B is a diagram for explaining the image capturing mode of the imaging function in the second operation mode of the cellular phone according to the embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

Hereinafter, an embodiment of the present invention will be described.

Embodiment

A cellular phone **10** as an embodiment of the present invention, whose exterior member is watertightly constructed, is operable in water.

As illustrated in FIGS. **1**A and **1**B, the cellular phone **10** has a first casing **20** and a second casing **30**. The first and second casings **20** and **30** are coupled to each other via a hinge **40** so that they are opened/closed. The cellular phone **10** is a folding type.

The first casing **20** is provided with a display device **21**, a speaker **22**, an alarm outputter **23**, and an imager **25** (refer to FIG. **1**B). The second casing **30** is provided with a console **31**, a microphone **32**, and a water sensor **35**. In the second casing **30**, a vibrator **34** is provided.

The display device **21** is provided in a center part of a front face **20***a* of the first casing **20**. The display device **21** is an LCD (Liquid Crystal Display) and displays characters, numerals, signs, images, and the like. The speaker **22** is disposed upper than the display device **21** and outputs various sounds. The alarm outputter **23** is disposed in a right side face **20***b* of the first casing **20** and outputs various alarms, ringtones, and the like. The imager **25** is provided in a rear face **20***c* of the first casing **20**, constructed by a lens unit **26**, a CMOS (Complementary Metal Oxide Semiconductor) image sensor (not illustrated), and the like, and captures a moving picture and a still picture.

The console **31** is provided in a center of a front face **30***a* of the second casing **30** and is constructed by a plurality of buttons and a switch. The user is able to enter characters, numerals, signs, and the like via the console **31**. The console **31** also has a function as a shutter button of the imager **25**.

The microphone **32** is provided below the console **31**. The microphone **32** converts voice that is entered into an electric signal and outputs the electric signal to a transceiver **120**. The vibrator **34** notifies reception of a signal by making vibrations at the time of reception of a signal or the like.

The water sensor **35** is provided in a right side face **30***b* of the second casing **30**. As illustrated in FIG. **1**C, the water sensor **35** has electrodes **36** and **37** and a low-dielectric-constant circuit board **38**. The two electrodes **36** and **37** are disposed closely in parallel to each other on the circuit board **38** and exposed to the outside. The water sensor **35** detects whether the cellular phone **10** is immersed in water or not on the basis of electric resistance between the two electrodes **36** and **37**. Concretely, in the case where the cellular phone **10** is in air, current hardly flows across the electrodes **36** and **37**, so the water sensor **35** detects electric resistance that is close to infinity. On the other hand, in the case where the cellular phone **10** is in water, the water sensor **35** detects electric resistance that is smaller than the above-described electric resistance.

As illustrated in FIG. **2**, the cellular phone **10** having the above-described configuration has a controller **100**, a storage **110**, the transceiver **120**, and a power supply **150**. To the controller **100**, the storage **110**, the transceiver **120**, the display device **21**, the speaker **22**, the alarm outputter **23**, the imager **25**, the console **31**, the microphone **32**, the vibrator **34**, and the water sensor **35** are connected.

The controller **100** has a CPU (Central Processing Unit) **101**, a ROM (Read Only Memory) **102**, and a RAM (Random Access Memory) **103**. The controller **100** controls the operations of the units connected.

The CPU **101** executes the OS (Operating System) and various programs such as an application program. The ROM **102** stores the various programs that are executed by the CPU **101**. The RAM **103** is used as a work area of the CPU **101**.

The storage **110** has a data area and a program area and stores various data and programs. For example, in the data area, a first operation mode table **50**, a second operation mode table **51**, and a reception mode table **60** that is illustrated in FIG. **4** are provided. In the program area, a program for realizing the embodiment in accordance with an operation procedure that will be described later is stored.

As illustrated in FIG. **3**A, the first operation mode table **50** specifies whether each of the functions of the cellular phone **10** is usable in a first operation mode (operation mode when the cellular phone **10** is above the ground). Name data of each of the functions of the cellular phone **10** and data indicating whether the function is valid or not in the first operation mode is stored so as to be associated with each other.

The first operation mode table **50** is referred to when the controller **100** sets the cellular phone **10** in the first operation mode. For example, as illustrated in FIG. **3**A, when "verbal communication function" and "ON" are associated with each other, the controller **100** sets the verbal communication function of the cellular phone **10** to be usable when the first operation mode is set.

On the other hand, as illustrated in FIG. **3**B, the second operation mode table **51** specifies whether each of the functions of the cellular phone **10** is usable in a second operation mode (operation mode when the cellular phone **10** is in water). Like in the first operation mode, name data of each of the functions of the cellular phone **10** and data indicating whether the function is valid or not in the second operation mode is stored so as to be associated with each other.

The second operation mode table **50** is referred to when the controller **100** sets the cellular phone **10** in the second operation mode. For example, as illustrated in FIG. **3**B, when "verbal communication function" and "OFF" are associated with each other, the controller **100** sets the verbal communication function of the cellular phone **10** to be unusable when the second operation mode is set. An operation mode setting process will be described later with reference to a flowchart.

Referring again to FIG. **2**, the transceiver **120** repeats receiving operation every predetermined time and captures communication radio waves from a basestation. The transceiver **120** has the functions of signal modulation/demodulation, frequency conversion, power amplification, and the like and transmits/receives radio waves via an antenna. That is, the transceiver **120** demodulates the radio wave received via the antenna to a sound signal, demodulates a signal from the controller **100**, and transmits a radio wave via the antenna.

Further, the transceiver **120** measures the strength of the received communication radio wave, that is, RSSI (Receive Signal Strength Indication). The transceiver **120** measures whether the RSSI is lower than a threshold level preliminarily stored in the storage **110** or not. In the case where the transceiver **120** detects the RSSI lower than the threshold level, the cellular phone **10** is so-called out-of-service or in a state close to the out-of-service. On the other hand, in the case where the transceiver **120** detects the RSSI equal to or higher than the threshold level, the cellular phone **10** exists in the so-called within communication range. The threshold level is preliminarily determined on the basis of a level necessary to reliably capture information transmitted from the basestation.

The transceiver **120** has a timer **121** for measuring radio wave reception time. The transceiver **120** refers to the reception mode table **60** illustrated in FIG. **4** and selects either continuous reception or intermittent reception. In the reception mode table **60**, data specifying the reception mode of the transceiver **120** in each of the operation modes is stored. In the case where the cellular phone **10** is in the first operation mode, the continuous reception mode is set, and the transceiver **120** continuously receives signals, for example, every 10μ seconds. In the case where the cellular phone **10** is in the second operation mode, the intermittent reception mode is set, and the transceiver **120** intermittently receives signals, for every one second.

The power supply **150** has a battery **151** and supplies drive power to the controller **100**.

Next, a process of setting the operation mode of the cellular phone **10** will be described with reference to the flowchart of FIG. **5**. The cellular phone **10** is set in the first operation mode (refer to FIG. **3**A) when the power is turned on.

First, the CPU **101** makes the transceiver **120** execute receiving operation every predetermined time, for example, every 100 ms to receive a signal from a wireless basestation (step S**101**).

The CPU **101** makes the transceiver **120** determine whether or not the RSSI is lower than the threshold level that is preliminarily stored in the storage **110** (step S**102**). In the case where the transceiver **120** determines that the RSSI of a received radio wave is lower than the threshold level that is preliminarily stored in the storage **110** (Yes in step S**102**), that is, in the case where the cellular phone **10** is in the so-called out-of-service state or a state close to the out-of-service, the flow shifts to step S**103**.

On the other hand, in the case where the RSSI is equal to or higher than the threshold level (No in step S**102**), that is, in the case where the cellular phone **10** exists within the communication range, the CPU **101** sets the operation mode to the first operation mode (step S**104**), sets the reception mode of the transceiver **120** to the continuous reception mode with reference to the reception mode table **60** (step S**105**), and temporarily finishes the process.

In step S**103**, the CPU **101** makes the water sensor **35** operate. Concretely, the CPU **101** applies voltage across the electrodes **36** and **37** of the water sensor **35**.

The water sensor **35** measures electric resistance between the two electrodes **36** and **37** and determines whether the measured electric resistance is smaller than a reference value or not, for example, whether the electric resistance is close to 0Ω not (step S**106**). In the case where the electric resistance between the two electrodes **36** and **37** is smaller than the reference value (Yes in step S**106**), that is, in the case where water exists between the two electrodes **36** and **37**, the flow shifts to step S**107**.

On the other hand, in the case where the electric resistance between the two electrodes **36** and **37** is equal to or larger than the reference value (No in step S**106**), that is, in the case where no water exists between the two electrodes **36** and **37**, the CPU **101** stops the water sensor **35** (step S**108**). The CPU **101** sets the operation mode to the first operation mode (step S**104**) and sets the reception mode of the transceiver **120** to the continuous reception mode with reference to the reception mode table **60** (step S**105**). The CPU **101** temporarily finishes the process.

In step S**107**, the CPU **101** sets the operation mode of the cellular phone **10** to the second operation mode (refer to FIG. **3**B).

The CPU **101** sets the reception mode of the transceiver **120** to the intermittent reception mode with reference to the reception mode table **60** (step S**109**) and finishes the setting of the operation mode of the cellular phone **10**.

By the above operation, the cellular phone **10** is set in the first or second operation mode. The CPU **101** determines whether each of the functions of the cellular phone **10** is validated or not on the basis of the set operation mode.

Next, the operation of the cellular phone **10** when each of the functions is used after the operation mode is set will be described with reference to the flowchart of FIGS. **6**A and **6**B. First, email receiving process will be described. As a premise, as illustrated in FIG. **3**A, the email function is set to the on state in the first operation mode and is set to the off state in the second operation mode.

As illustrated in FIG. **6**A, the CPU **101** executes the operation mode setting process (refer to FIG. **5**) and, after that, determines whether the present operation mode is the first operation mode or not (step S**201**). In the case where the present operation mode is the first operation mode (Yes in step S**201**), the CPU **101** instructs the transceiver **120** to receive an email (step S**202**). On the other hand, in the case where the present operation mode is not the first operation mode (No in step S**201**), that is, is the second operation mode, the CPU **101** finishes the process.

In the embodiment, calling process, recording process, and call-reception vibrating process of the cellular phone **10** are set to the on state in the first operation mode and are set to the off state in the second operation mode like in the above-described email receiving process. Since the processes are similar to the above-described email receiving process, the description will not be repeated.

The imaging process that is set to the on state in the first and second operation modes will now be described.

As illustrated in FIG. **6**B, regardless of whether the present operation mode is the first or second operation mode, the CPU **101** instructs the imager **25** to capture an image (step S**301**), and finishes the imaging process of the cellular phone **10**.

As described above, the functions that do not have to be operated in water are regulated in the second operation mode. Consequently, it is effective to reduce consumption power.

Further, in the cellular phone **10** of the embodiment, the water sensor operates only in the case where the cellular phone **10** is so-called out-of-service or in a state close to the out-of-service state. Therefore, power consumed by continuous operation of the water sensor is able to be reduced.

In the cellular phone **10** of the embodiment, only in the case where the RSSI of a received radio wave is lower than the threshold level and water is sensed by the water sensor, the operation mode is set to the second operation mode. In such a manner, even when the cellular phone **10** is used underground or the like where a radio wave is not easily received, the operation mode is not set to the second operation mode, so the convenience for the user is not deteriorated.

The present invention is not limited to the foregoing embodiment and is able to be variously modified.

In the foregoing embodiment, in the first or second operation mode, each of the functions of the cellular phone **10** is set to either ON or OFF. However, the setting of the operation mode as in the embodiment is an example, and the invention is not limited to the setting. Each of the functions is set to ON in both of the first and second operation modes, and the operations of the functions are varied, in some cases.

For example, in the imaging function, imaging parameters suitable for imaging out of water are specified in the first operation mode, and imaging parameters suitable for imaging in water are specified in the second operation mode, in some cases.

In this case, in the data area of the storage **110**, a first imaging mode table **70** illustrated in FIG. **7**A and a second imaging mode table **71** illustrated in FIG. **7**B are provided.

In the first imaging mode table **70**, each of the imaging parameters in the first operation mode of the cellular phone **10** and data specifying an imaging mode in the first operation mode are stored so as to be associated with each other. In the first operation mode, imaging parameters such as an aperture value, shutter speed, and a value of ISO (International Organization for Standardization) sensitivity are set so as to be adapted to imaging operation above ground.

In the second imaging mode table **71**, each of the imaging parameters in the second operation mode of the cellular phone **10** and data specifying an imaging mode in the second operation mode are stored so as to be associated with each other. In the second operation mode, imaging parameters are set so as to be adapted to imaging operation in water. In the imaging parameters, for example, the shutter speed is set to be faster than that in the first operation mode, and the value of ISO sensitivity is set to be higher than that in the first operation mode. By the settings, a picture with little blurring caused by hand movement is able to be taken.

As described above, when the cellular phone **10** is immersed in water, the operation mode is changed from the first operation mode to the second operation mode. Consequently, the operation mode is automatically set so as to be suitable to underwater imaging, and the usability of the cellular phone **10** improves.

Although the water sensor **35** used in the foregoing embodiment detects whether the cellular phone **10** is immersed in water or not by measuring electric resistance between the two electrodes **36** and **37**, the invention is not limited to the detection. Whether the cellular phone **10** is immersed in water or not is detected by measuring pressure by a pressure sensor, in some cases. For example, in the case of using a semiconductor pressure sensor using a silicon diaphragm as a pressure sensor, the diaphragm is disposed on the outer face of the casing of an electronic device, in some cases. In the case where the electronic device is immersed in water, the diaphragm is deformed by water pressure. By detecting the deformation amount as an amount of change in voltage in a Wheatstone bridge circuit disposed on the diaphragm, whether the cellular phone **10** is immersed in water or not is able to be detected.

In the embodiment, the threshold level is preliminarily determined on the basis of a level necessary to always reliably catch a radio wave from a basestation. The threshold level, however, is not limited to the above but is able to be arbitrarily set.

In the embodiment, all of the functions are set to the on state in the first operation mode. Only the imaging function is set to the on state and the other functions are set to the off state in the second operation mode. The invention is not limited to the setting. The on/off state of each of the functions in the first and second operation modes is able to be arbitrarily set.

The present invention is able to be applied to electronic devices such as various cellular phones, a PHS (Personal Handyphone System), a PDA (Personal Digital Assistant), a smartphone, a notebook-sized personal computer, and the like. That is, the above-described embodiment is provided for explanation and does not limit the scope of the present invention. Therefore, a person skilled in the art is able to employ embodiments obtained by replacing any or all of the elements to equivalents of embodiments to be described later, and the present invention also includes those embodiments.

A part or all of the foregoing embodiment is able to be also described as follows but the invention is not limited to the below.

Supplementary Note **1**

An electronic device that is able to operate in water, including:

communication means that receives a radio wave;

water detection means that detects whether the electronic device is immersed in water or not; and

control means that makes the water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level.

Supplementary Note **2**

The electronic device described in Supplementary Note **1**, wherein the control means supplies power to the water detection means to make the water detection means operate.

Supplementary Note **3**

The electronic device described in Supplementary Note **1** or **2**, wherein the electronic device is able to be set, by the control means, in a first operation mode of specifying whether a predetermined function of the electronic device out of water is valid or not and a second operation mode of specifying whether a predetermined function of the electronic device in water is valid or not and,

in the case where the water detection means detects that the electronic device is immersed in water, the control means sets the electronic device into the second operation mode.

Supplementary Note **4**

The electronic device described in Supplementary Note **3**, wherein a plurality of functions are set to be valid or invalid in the first and second operation modes, and

a function specified to be valid in the second operation mode is a part of functions specified to be valid in the first operation mode.

Supplementary Note **5**

The electronic device described in Supplementary Note **3** or **4**, further including image capturing means,

wherein the first operation mode is a mode of specifying an imaging parameter of the image capturing means out of water, and the second operation mode is a mode of specifying an imaging parameter of the image capturing means in water.

Supplementary Note **6**

The electronic device described in Supplementary Note **5**, wherein the imaging parameter is shutter speed of the image capturing means, and shutter speed specified in the second operation mode is faster than shutter speed specified in the first operation mode.

Supplementary Note **7**

The electronic device described in Supplementary Note **5**, wherein the imaging parameter is a value of ISO sensitivity of the image capturing means, and a value of ISO sensitivity specified in the second operation mode is higher than value of ISO sensitivity specified in the first operation mode.

Supplementary Note **8**

A method of controlling water detection means, including:

a step of receiving a radio wave by communication means; and

a step of making water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level.

Supplementary Note **9**

The method of controlling water detection means described in Supplementary Note **8**, further including a step of supplying power to the water detection means in order to make the water detection means operate.

Supplementary Note **10**

A method of setting an operation mode of an electronic device that is able to operate in water and is able to be set in two operation modes, including:

a step of receiving a radio wave by communication means;

a step of making water detection means operate in the case where intensity of a reception signal of a radio wave received by the communication means is lower than a threshold level; and

a step of changing the operation mode of the electronic device from one of the operation modes to the other operation mode in the case where the water detection means detects that the electronic device is immersed in water.

The present invention is based on Japanese Patent Application No. 2011-026390 filed on Feb. 9, 2011. The specification, the scope of claims for patent, and the drawings of Japanese Patent Application No. 2011-026390 are incorporated herein as reference in its entirety.

INDUSTRIAL APPLICABILITY

The present invention is useful to use an electric device in water with reduced electric power.

DESCRIPTION OF REFERENCE NUMERALS

10 Cellular phone
20 First casing
21 Display device
22 Speaker
23 Alarm outputter
25 Imager
26 Lens unit
30 Second casing
31 Console
32 Microphone
34 Vibrator
35 Water sensor
36 Electrode
37 Electrode
38 Circuit board
40 Hinge
50 First operation mode table
51 Second operation mode table
60 Reception mode table
70 First imaging mode table
71 Second imaging mode table
100 Controller
101 CPU
102 ROM
103 RAM
110 Storage
120 Transceiver
121 Timer
150 Power supply
151 Battery

The invention claimed is:

1. An electronic device that is able to operate in water, comprising:

communication means that receives a radio wave;

water detection means that detects whether the electronic device is immersed in water or not; and

control means that makes the communication means determine whether or not intensity of reception signal of a radio wave received by the communication means is lower than a threshold level;

wherein the communication means determines whether or not the intensity of the reception signal of a radio wave is lower than the threshold level: and

the control means makes the water detection means operate if the communication means determines that the intensity of the reception signal of a radio wave is lower than the threshold level.

2. The electronic device according to claim **1**, wherein the control means supplies power to the water detection means to make the water detection means operate.

3. The electronic device according to claim **1**, wherein the electronic device is able to be set, by the control means, in a first operation mode of specifying whether a predetermined function of the electronic device out of water is valid or not and a second operation mode of specifying whether a predetermined function of the electronic device in water is valid or not and,

in the case where the water detection means detects that the electronic device is immersed in water, the control means sets the electronic device into the second operation mode.

4. The electronic device according to claim **3**, wherein a plurality of functions are set to be valid or invalid in the first and second operation modes, and

a function specified to be valid in the second operation mode is a part of functions specified to be valid in the first operation mode.

5. The electronic device according to claim **3**, further comprising image capturing means,

wherein the first operation mode is a mode of specifying an imaging parameter of the image capturing means out of water, and the second operation mode is a mode of specifying an imaging parameter of the image capturing means in water.

6. The electronic device according to claim **5**, wherein the imaging parameter is shutter speed of the image capturing means, and shutter speed specified in the second operation mode is faster than shutter speed specified in the first operation mode.

7. The electronic device according to claim **5**, wherein the imaging parameter is a value of ISO sensitivity of the image capturing means, and a value of ISO sensitivity specified in the second operation mode is higher than value of ISO sensitivity specified in the first operation mode.

8. A method of controlling water detection means, comprising:

a step of receiving a radio wave by communication means;

a step of determining whether or not intensity of a reception signal of a radio wave is lower than a threshold level by the communication means; and

a step of making water detection means operate if the communication means determines that intensity of the reception signal of a radio wave received by the communication means is lower than the threshold level.

9. The method of controlling water detection means according to claim **8**, further comprising a step of supplying power to the water detection means in order to make the water detection means operate.

10. A method of setting an operation mode of an electronic device that is able to operate in water and is able to be set in two operation modes, comprising:

a step of receiving a radio wave by communication means;

a step of determining whether or not intensity of a reception signal of a radio wave is lower than a threshold level by the communication means:

a step of making water detection means operate if the communication means determines that intensity of the

reception signal of a radio wave received by the communication means is lower than the threshold level; and

a step of changing the operation mode of the electronic device from one of the operation modes to the other operation mode if the water detection means detects that the electronic device is immersed in water.

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